Experimental Microthruster Evaluation at Simulated Orbital Conditions

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Why try to measure a force equivalent to the weight of a paper clip? In the absence of gravity, such minuscule forces can accomplish impressive tasks, like correcting the position of a satellite in Earth orbit. "Microthrusters" is the term given to the class of nozzles that generate these microforces, and are generally classified by a throat Reynolds Number of below 10,000. To quantify the performance characteristics, MSFC maintains test equipment to evaluate microthrusters at simulated orbital conditions.

Experiments are conducted in a 5-cubic-meter vacuum chamber with diffusion pumps capable of evacuating air at 196 cubic meters per second to a chamber pressure of 1E–7 millimeters of mercury absolute. This pressure simulates the density of the atmosphere at approximately 200 miles altitude. A force stand in the chamber measure microthruster forces over a range of 5 to 3,000 dynes. Supporting instrumentation measures gas flow rate, model pressures, and chamber pressure.

The most recent addition to the MSFC data base is the microthruster for the Gravity Probe B Space Science satellite (fig. 91). The Gravity Probe B is designed to watch the position of a gyro as it orbits the Earth, looking for slight changes as predicted by relativity theory. The satellite's microthrusters are being designed and built by Lockheed–Palo Alto, California. The original purpose of the MSFC testing was to provide an independent confirmation of the microthruster's performance, but grew into a test-bed service for Lockheed when they need to change the design. The test matrix consisted of five plenum pressures versus 18 flow rates. Thrust and discharge coefficients were found to be highly dependent on the throat Reynolds number. The performance was further benchmarked by comparison with a classic sharp-edged orifice nozzle (fig. 92).

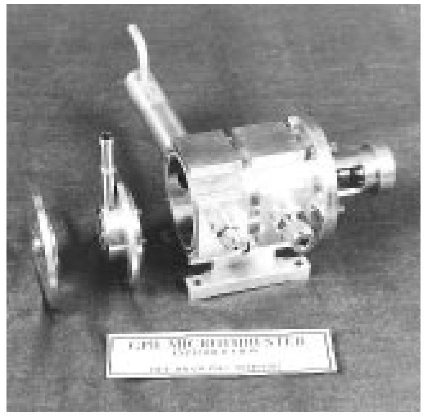

FIGURE 91.—Gravity Probe B microthruster model: exploded view.

MSFC's orbital simulation facilities will continue to be used to participate in analytical studies (Droege),[1] conduct fundamental research (Russell),[2] and provide private industry a test-bed service (Carter).[3]

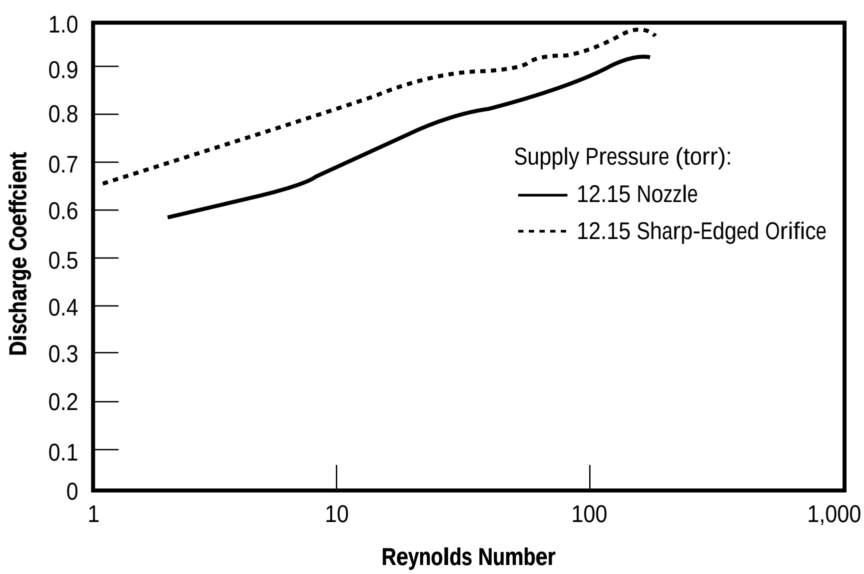

FIGURE 92.—Laval nozzle versus sharp-edged orifice: discharge coefficient = F(Reynolds No.).

[1]Droege, A. 1994. Direct Simulation Monte Carlo Analysis of Microthruster Rarefied Flow Characteristics. *Research and Technology 1994*, 208–209.

[2]Russell, C. 1992. Welding in Space Experiments, EH25.

[3]Carter, J. 1995. Experimental Study of the Performance of Gravity Probe B Microthruster. NAS8–39743 Task 034 Final Report.

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Industry Involvement: Lockheed–Palo Alto, California